1. Steam System

1. Steam System

1.1 System Description

Steam is generated by a set of six (6) boilers located in the Central Energy Plant (CEP). Four (4) of the boilers are sized to serve the Building 215. Two (2) boilers are sized to serve the Acute Care Facility (ACF).

The steam system is controlled and monitored by a DCCS. Refer to *Chapter 16: Distributed Computer Control System.*

The boilers are dual-fuel, meaning either natural gas or #2 oil can be used to fire the boiler. Steam is generated by the boilers at approximately 125 psig and distributed by a common header. Steam is then supplied to serve the following functions:

- Heating hot water for the Acute Care Facility (ACF)
- Domestic hot water for the ACF
- Clean steam generation for the ACF
- Space heating in the CEP
- Autoclaves in the CEP
- Deaerator in the CEP
- Fuel Atomization in the boilers
- Soot blowers on the boilers

Steam generated by the boilers is supplied to a common header before further distribution. There are five (5) pressure reducing stations in the plant serving various areas. The following steam pressure reducing valves are present in the system:

Valve #	**Inlet/Outlet Pressure (psig)**	**Area Served**	**Location**
PCV 0069	125/60	Barton Street	
PCV 0074	125/60	Autoclaves & Domestic HW Heaters	
PCV 0076	125/60	Autoclaves & Domestic HW Heaters	
PCV 0070	125/5-12	Deaerator Heater	CEP Mezzanine
PCV 0072	125/12	Building HVAC System	

Major Equipment Descriptions:

- Boilers

  There are six boilers with a total installed capacity of 190,000 pounds per hour (pph) of steam at 125 psig. Three boilers are rated at 30,000 pph each, one at 20,000 pph and two at 40,000 pph each. Boilers are water-tube D-type, of standard package design. Each boiler is fitted with a water column, gauge glass, drum level control valve, soot blowers and forced draft fans. Boilers B-105, B-106 and B-107 are provided with economizers. There are two seal air fans serving the boilers.

- Burners

  The boilers are provided with low NOx, dual-fuel burners with provisions for air and steam atomization. Either natural gas or #2 oil can be used to fire the burner. The boiler plant has a microprocessor-based burner management system.

- Tube Cleaner

  The tube cleaner is a water-driven type designed for 2 inch outside diameter tubes with wall thickness of 0.105 inch. It requires 6.2 gallons per minute of water at a pressure of 150 psig.

- Soot Blower

  Each boiler is provided with a soot blower for cleaning the surfaces of steam generating tubes.

- Chemical Treatment

  Boiler chemical treatment consists of sulphite that is injected into the boiler drum.

1.2 Normal Operating Conditions

Feedwater from the deaerator enters the boilers via the feedwater control valves. Steam is generated at 125 psig. High pressure steam (125 psig) is supplied to buildings 1, 2, & 5 and the Acute Care Facility (ACF). High pressure steam is also utilized for soot blowers, boiler fuel oil atomization and hot water heaters. Medium pressure steam (60 psig) is supplied to Barton Street, the autoclaves and the domestic hot water heaters. Low pressure steam (12 psig) is supplied to deaerators and the CEP's heating, ventilating and air conditioning systems.

Once the number of boilers are put on line manually, the DCCS maintains the header pressure based on the steam demand and changes the boilers to low/high fire as required. Natural gas is the main fuel and fuel oil # 2 is the alternate. Natural gas is provided on an interruptible basis.

1.2.2 Modes of Operation

Burners are provided with compressed air and high pressure steam for atomization of fuel when fuel oil is burnt.

Whenever fuel oil is burned in the boilers, prior to boiler shutdown or transfer to natural gas firing, soot blowers are operated to clear the boiler tubes. Soot blowers are supplied with high pressure steam.

Each boiler is provided with a boiler master control panel.

Boilers are operated throughout the year at a constant pressure of 125 psig.

The boiler master control panel is comprised of all the essential boiler operating and monitoring functions. A boiler master control panel is provided for each boiler. The controllers are as follows:

- Boiler master
- Gas flow
- Fuel oil flow
- Air flow
- Oxygen (trim)
- Drum level (two element feedwater)

1. Boiler Master Controller

The firing rate demand generated by the plant master control loop is directed to the fuel (natural gas or fuel oil) and the air controllers via a boiler master controller station. Consequently, the firing rate on the boiler(s) is modified as dictated by the steam header pressure as maintained by the DCCS. The boiler master station

provides manual or automatic functions plus a bias capability. The biasing capability permits the carrying of equal, lesser, or greater loads on any selected boiler relative to the other boilers as controlled by the DCCS. The boiler master controller incorporates two special interlocks.

- It is interlocked with the air flow controller and cannot be placed into the automatic mode until the air controls are placed in automatic position. Consequently, placing the air controls into the manual position will automatically place the boiler master into manual operation.

- Prior to and during boiler light-off the boiler master controller will hold a low fire position output until it receives a release for modulation input from the burner management flame safety system. The output of the boiler master during low fire hold should equal the same value as the forced draft damper position setting for low fire.

Should the boiler master controller be left in the automatic mode prior to boiler light-off it will hold the low fire position described above until it receives the release signal for modulation input. Upon receiving a release signal it will satisfy (ramp to) the plant master output value plus any bias that may have been set on the boiler master.

Should the boiler master controller be left in the manual mode prior to boiler light-off it will hold the low fire position until it receives the release signal for modulation input. The operator is then responsible to place the controls in automatic if desired.

2. Natural Gas Flow Controller (main fuel)

The firing fuel (natural gas or fuel oil) must be selected prior to boiler start-up. The fuel selection switch is located in the burner management flame safeguard section of the respective boiler master control panel.

The firing rate demand from the boiler master controller is directed to the natural gas flow controller via a low signal selector in which the second input is measured air flow. This signal selector limits the demand for natural gas fuel to a value no greater than that for which there is sufficient combustion air. The signal selector output is then compared with measured fuel flow in a proportional plus integral controller which insures that fuel input to the burner is equal to the demanded fuel.

A manual/automatic station for the natural gas fuel flow controller provides the manual/automatic function as described above for steam flow under the plant master controller.

The natural gas flow controller incorporates three special interlocks:

- It is interlocked with the air flow controller and cannot be placed in the automatic mode until the air controls are placed into the automatic position. Consequently, placing the air controls into the manual position will automatically place the natural gas flow controller into manual operation.

- Prior to and during boiler light-off the natural gas flow controller will hold a low fire position output until the low fire hold interlock is disabled by the burner management flame safety system. This will only occur if natural gas is the selected fuel. If fuel oil is the selected fuel, the output to the gas valve will remain in its last position locked into the manual mode.

- When the natural gas flow controller is left in the automatic mode prior to boiler light-off, it will hold the low fire position described above until the low fire hold is disabled. Once the low fire hold is disabled the natural gas flow controls will satisfy (ramp to) the fuel set point as determined by the cross limiting logic control. For a definition of "cross limiting control" see note below.

  This controller also incorporates logic to totalize the natural gas fuel flow and display & record the amount of fuel consumed on a circular chart recorder and a digital panel meter.

- *Note on Cross Limiting Control: In order to reduce the possibility of a furnace explosion and reduce stack emissions the following fuel to air control sequences will occur and are hereafter referred to as cross limiting.*

  - *Any increase in the fuel rate will be preceded by an increase in air flow rate.*

  - *Any decrease in the fuel rate will be preceded by a decrease in air flow rate.*

3. Fuel Oil Flow Controller (alternate fuel)

The firing fuel (natural gas or fuel oil) must be selected prior to boiler start-up. The fuel selection switch is located in the burner management flame safeguard section of the respective boiler master control panel.

The firing rate demand from the boiler master controller is directed to the fuel oil flow controller via a low signal selector in which the second input is measured air flow. This signal selector limits the demand for fuel oil fuel to a value no greater than that for which there is sufficient combustion air. The signal selector output is then compared with measured fuel flow in a proportional plus integral controller which insures that fuel input to the burner is equal to the demanded fuel.

A manual or automatic station for the fuel oil flow controller provides the basic manual or automatic functions as described above for steam flow under the plant master controller.

The fuel oil flow controller incorporates three special interlocks.

- It is interlocked with the air flow controller and cannot be placed into the automatic mode until the air controls are placed into the automatic position. Consequently, placing the air controls into the manual position will automatically place the fuel oil flow controller into manual operation.

- Prior to and during boiler light-off the fuel oil flow controller will hold a low fire position output until the low fire hold interlock is disabled by the burner management flame safety system. This will only occur if fuel oil is the selected fuel. If natural gas is the selected fuel the output to the fuel oil valve will remain in its last position locked into in the manual mode.

- When the fuel oil flow controller is left in the automatic mode prior to boiler light-off, it will hold the low fire position described above until the low fire hold is disabled. Once the low fire hold is disabled the fuel oil flow controls will satisfy (ramp to) the fuel set point as determined by the cross limiting logic control.

  When the fuel oil flow controller is in the manual mode prior to light-off it will hold the low fire position until the low fire hold input is disabled. The operator is then responsible to place the controls in automatic position if desired.

  This controller also incorporated logic to totalize the fuel flow and display & record the amount of fuel consumed on a circular chart recorder and digital panel meter.

4. Air Flow Controller

The firing rate demand from the boiler master controller is directed to the air flow controller via a high signal selector (cross limiting control) in which the second input is measured fuel (fuel oil or natural gas) flow. This signal selector maintains the demand for air to a value no less than that required for combustion of the fuel input. The output of the signal selector is compared with measured air flow (multiplied for optimum excess air) in a proportional plus integral controller which modifies the forced draft fan damper to a position which results in measured air flow equaling demanded flow. A manual/automatic station for the air flow controller provides the basic manual or automatic functions as described above for steam flow under plant master controller.

The air flow controller incorporates three special interlocks:

- Prior to boiler light-off the air flow controller will position the force draft damper for boiler purge. This will occur automatically via an input interlock from the burner management flame safety system. The forced draft fan damper will remain in the purge position until the flame safety system disable the purge input.

- Prior to and during boiler light-off the air flow controller will hold a low fire position output until the low fire hold interlock is disabled by the flame safety system.

- An input signal will be sent to the air flow controller whenever a fuel is selected (fuel oil or natural gas) at the burner management flame safety system selector switch.

When the air flow controller is left in the automatic mode prior to boiler light-off it will hold the low fire position described above until the low fire hold is disabled. Once the low fire hold is disabled, the air flow controls will satisfy (ramp to) the air set point as determined by the cross limiting logic control.

When the air flow controller is in the manual mode prior to light-off it will hold the low fire position until the low fire hold input is disabled. The operator is then responsible to place the controls into the automatic position if desired.

5. Oxygen (Trim) Controller

Excess air is controlled to the most favorable value by controlling measured flue gas oxygen content to a load generated set point. The set point will decrease with an increasing load and can be manually biased. For a definition of "excess air" see note below.

Measured oxygen is compared with the set point (in a proportional plus integral controller which generates a multiplying factor) for measured air flow prior to it being compared with the firing rate demand.

The net result will be the varying of excess air and maintaining both the oxygen and air flow controllers in balance. A manual/automatic station for the oxygen trim controller is included to perform the manual functions.

When in the "manual" mode, the station becomes a manual fuel/air ratio adjuster. Adjusting the output from 50% to 100% will result in decreasing oxygen. Conversely, adjusting the output from 50% to 0% will result in increasing oxygen.

The oxygen trim controller incorporates three special interlocks.

- It is interlocked with air flow controller and cannot be placed in the automatic mode until the air controls are placed in automatic position.

Consequently, placing the air controls into manual position will automatically place the oxygen trim controller into manual and thereby automatically drive the fuel/air ratio output to a neutral 50% value.

- Prior to and during boiler light-off the oxygen trim controller will hold the fuel/air ratio output at 50% until the low fire hold interlock is disabled by the burner management flame safety system.

- Since the load generated oxygen set point will be different depending on the fuel being fired, this controller will automatically select the proper operating set point curve based on the fuel selection input from the burner management flame safety system.

When the oxygen trim controller is left in the automatic mode prior to boiler light-off it will hold the neutral fuel/air ratio output until the low fire hold is disabled. Once the low fire hold is disabled the oxygen trim controls will satisfy (ramp to) the fuel/air ratio output in order to satisfy the load generated oxygen set point.

When the oxygen trim controller is in the manual mode prior to light-off it will hold the neutral fuel/air ratio output until the low fire hold input is disabled. The operator is then responsible to place the controls into automatic position if desired.

- *Note on Excess Air: The amount of air in excess of the theoretical air is call "excess air" and is usually expressed as a percentage of the theoretical air. The oxygen required for complete combustion must be obtained from the air supplied to the furnace. The amount of air required to supply just enough oxygen for complete combustion is called the "theoretical air". However, in actual practice it is necessary to supply more than this theoretical amount of air in order to make sure that all the particles of fuel come in contact with oxygen.*

6. Drum Level (Two Element Feedwater) Controller

The feedwater control system is a two-element system utilizing electronic signals proportionate to steam flow and drum level to control feedwater input to the drum. The system will compensate for the effects of "shrink" and "swell" on load changes.

During steady state conditions, with feedwater input at a value which maintains drum level at set point, the position demand for the feedwater valve is established by summing the signals, proportionate to steam flow plus a correcting signal to maintain drum level at set point value.

The demand signal for feedwater will limit the position of the feedwater valve in the direction which will result in feedwater flow approximately equaling to the

steam flow.

- On a load increase, steam flow increases and, due to the effect of "swell" in the drum, the drum level controller. This rise in drum level inhibits the opening of the feedwater valve until the swell effect is no longer present. Once the swell effect is gone, the level will decrease below the set point, due to the unbalance in the input and throughput. At the same time, the drum level controller will start to generate a correcting signal to bring drum level back to the set point value.

- On a load decrease, the reverse of the above occurs, with the closing of the feedwater valve delayed to allow for the effect of "shrink" in the drum. With the feedwater automatic/manual station in the "automatic" mode, the demand signal for feedwater flow is passed through unaltered. When the station is in the "manual" mode, the automatic signal is blocked and the feedwater valve must be manually positioned by the operator.

This controller also incorporates logic to totalize steam flow and display & record the amount of total steam generated on a digital panel meter.

Additionally, this controller includes a digital output of the boiler operating status. This signal indicates that the boiler steam flow has increased above the minimum steam flow requirement. The minimum value can be adjusted in the controller as required for proper plant operation.

7. Panel Gages

The boiler master control panels are provided with barograph indicating gages for various boiler operating conditions such as draft pressures, levels and sub-system pressures that are essential to the overall boiler operation. They are as follows:

- Windbox pressure
- Furnace pressure
- Economizer inlet pressure
- Economizer outlet pressure
- Drum level
- Drum pressure
- Feedwater pressure
- Fuel oil pressure

8. Panel Recorders

The boiler master control panels are also provided with 2-three pen and 2-two pen circular chart recorders. They are as follows:

- oil flow

- gas flow (natural gas)
- air flow
- economizer inlet temperature
- economizer outlet temperature
- feedwater temperature
- oxygen
- opacity (smoke density)
- feedwater flow
- steam flow

9. Annunciator Panalarm

The boiler master control panels are provided with an annunciator Panalarm that will alarm whenever a boiler and/or burner management safety condition has been violated. The safety conditions annunciated specifically address the boiler operation. Most of the annunciator alarm points are critical and will "prevent boiler start-up" or cause the "boiler to trip-out" (i.e., these conditions must be satisfied before the boiler will be enabled to start).

1.3 OMSI Drawings and Photographs

The following OMSI photographs are included for this system:

Figure 1: Boiler B-109 showing burner and forced draft fan at the top of the boiler (typical for Boiler B-110 and Boiler B-107)
Figure 2: Boiler B-106 showing burner and control panel on right side of boiler front (typical for Boiler B-105 and Boiler B-108)
Figure 3: Typical Pressure Reducing Valve

The following OMSI drawings have been developed for this system. They are located after the photographs:

ST-1 Steam System Flow Diagram
ST-2 Steam System Location Drawing

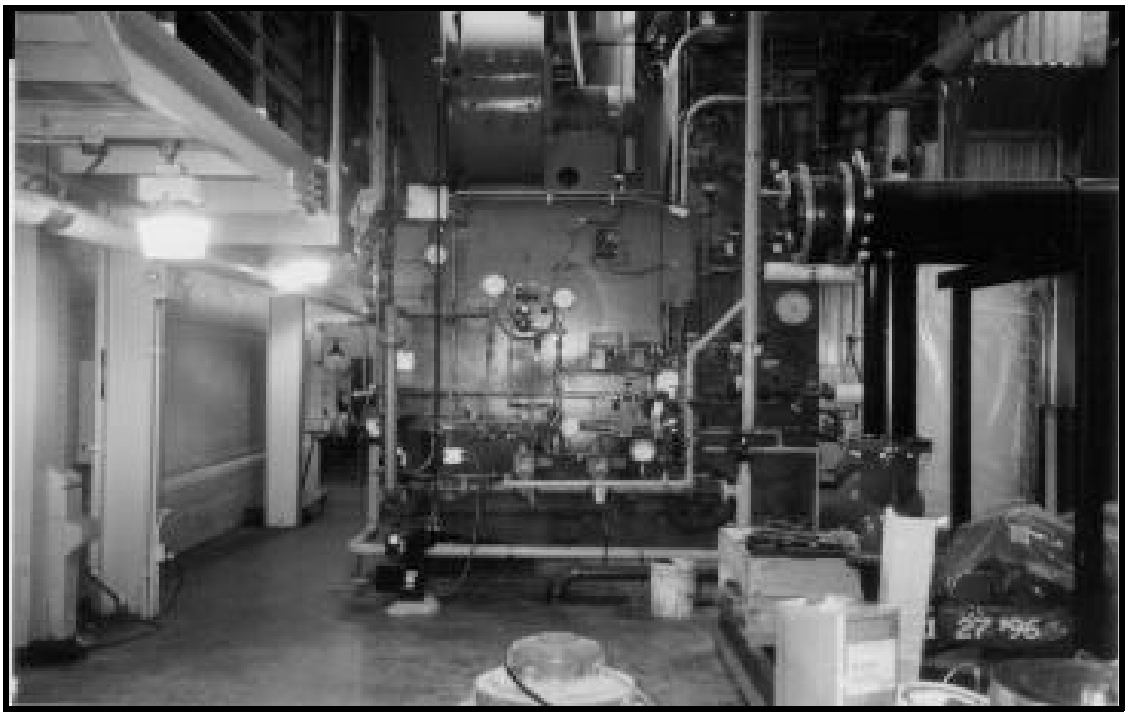

Figure 2: Boiler 109 showing burner and forced draft fan at the top of the boiler (typical for Boiler 110 and Boiler 107)

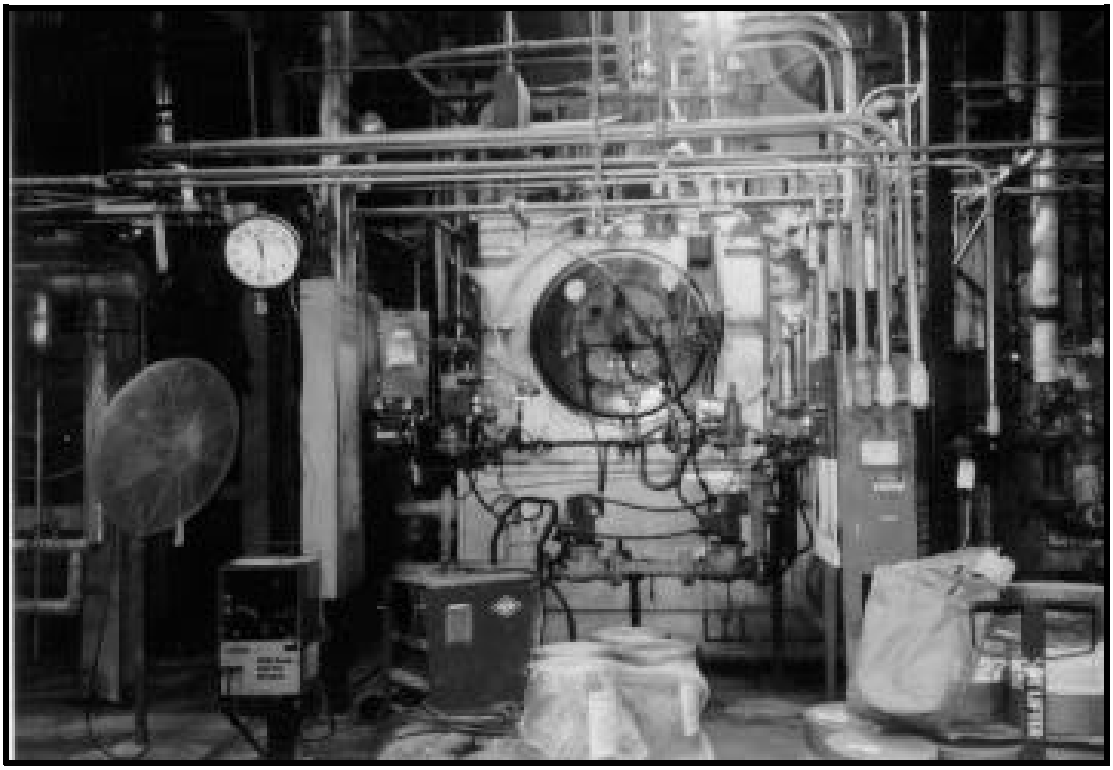

Figure 1: Boiler 106 showing burner and control panel on right side of boiler front (typical for Boiler 105 and Boiler 108)

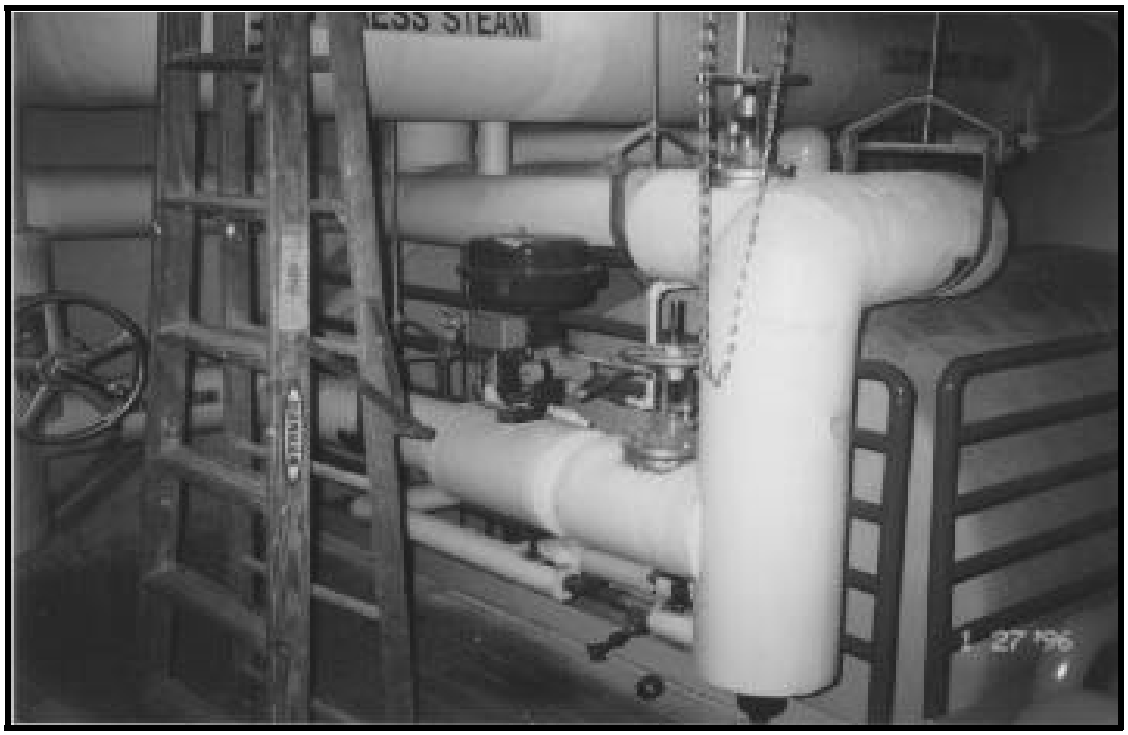

Figure 3: Typical Pressure Reducing Valve

1.4 System Startup and Shutdown Procedures

1.4.1 System Startup Procedure

The boilers are provided with boiler master control panels. These control panels monitor and control the operation of boiler plant auxiliaries. The following steps are provided as a guideline to starting the boilers:

1. Prepare the selected boiler and the auxiliaries for operation in accordance with the manufacturer's operating instructions prior to energizing.

2. Verify that control power is available to the boiler control panels.

3. Open the vent valve on the steam drum of the selected boiler. After the steam flow is established, close the vent valve.

4. Verify that a minimum water level of two (2) inches is established above the bottom of the gage glass in the selected boiler.

5. Verify that the selected boiler steam stop valves are closed, but not tightly sealed.

6. Prior to opening any steam stop valves on the selected boiler, verify that all condensate has been drained from the valves.

7. Open the bypass valve around the steam stop isolation valve of the selected boiler in order to warm up the steam lines and to equalize the pressures.

8. Prior to operating the deaerating heater, verify that all the piping and controls are functioning properly.

9. Prior to starting the feedwater pumps check that the pump and the respective piping and controls are all functioning properly.

10. Verify that the feedwater isolation valves in the piping to the boiler being served are in fully open position.

11. Boiler feed water is supplied to the boilers from the feedwater pumps as required. Each boiler is provided with a feedwater control valve that will modulate the feedwater flow to the boilers via a feedwater controller.

    The feedwater supply to a boiler is controlled by the respective boiler steam flow and boiler drum level. The feedwater control valve automatically modulates the flow to the respective boiler.

12. The boilers are provided with low water cut-out switches that will trip out the burner in the event that the water level drops below the bottom of the gage glass.

13. Boilers B-105, B-106, and B-107 are provided with economizers located in respective boiler breeching. Prepare the economizer in accordance with the manufacturer's instructions prior to boiler start-up.

    Ensure that the isolation valves around the economizer are in open position. The economizers are provided with feedwater bypass valves, should it be necessary to bypass the feedwater flow around the economizer during operation.

14. Open all the other manual isolation valves that are necessary, for the selected boiler.

15. Verify that the boiler burner system and the components and controls of the boiler to be started are functioning and operational.

    Check the following equipment:

    - Limit and firing controls (burner management/flame safeguard system).
    - Fuel oil pumps
    - Forced draft fan
    - All the dampers in the combustion air inlet and flue gas outlet.

16. The fuel (natural gas, including pilot gas and fuel oil) and the high pressure steam(for atomization) are each provided with self contained pressure regulating valves in the respective train piping to the burner. Verify that the pressure regulating valves are operational prior to energizing the burner.

17. When firing a boiler with natural gas the following items should be confirmed:

    - Natural gas is the main fuel
    - Natural gas is available and at the correct pressure (10 psig at the inlet to the gas train). Natural gas service is interruptible.
    - The high pressure steam valve for fuel oil atomization should be in fully closed position.
    - After all the fuel oil valves are closed, the blowout cock in the steam atomizing line should be opened in order to clean out the burner tip.
    - Verify that natural gas for the burner pilot is available.
    - Verify that the natural gas train piping to the burner is in order and functional.
    - Place the pilot shut-off plug cocks in open position.
    - Oil is used for ignitor pilot on boilers B-109 and B-110. Fuel oil service pump must be on line.

18. When firing with fuel oil the following items should be confirmed:

    - The fuel oil system is in order and functional.
    - Natural gas for the burner pilot is available.

- Natural gas train piping to the burner pilot is in order and functional.
- The fuel oil train piping to the burner is in order and functional.
- Place the high pressure steam valves to the burner, for atomization, in open position.
- Verify that natural gas isolation valves on the piping to the natural gas burner are in closed position.

19. When boiler drum pressure rises to 15 psig and steady flow of steam is visible from the vent, it indicates that all the air has been expelled from the steam drum. At this point close the steam drum vent valve.

20. Caution should be exercised in bringing the boiler up to full operating pressure of 125 psig. The maximum rate of increasing steam pressure should not exceed a 100°F per hour increase in saturation temperature.

21. In order to prevent the boiler stop valve from sticking during the pressure raising period, they should be checked frequently to verify that they are not seated too tightly.

22. The bypass valve across the stop valve should be used to equalize the pressures, thereby reducing the throttling action across the valve when it is opened.

23. When the boiler comes up to its full operating pressure of 125 psig, the stop valve should be opened slowly.

24. After the stop valve is fully open, the non-return valve should be opened slowly.

25. The boiler can now be operated automatically based on steam demand via the DCCS.

26. Prior to distributing steam to the system, place continuous blowoff valves into a full open position.

27. The make-up water/treated water service to the deaerating heater is operational.

28. The boilers are provided with soot blowers. They should be operated in accordance with the manufacturer's operating instructions.

29. Intermittent blowdown valves should be opened once every shift.

30. The boiler gage glass, water column, and low water level trip chamber should be blown down once daily. The low water cut out and alarm should also be tested daily.

1.4.2 System Shutdown Procedure

The following steps are provided as a guideline to shutting down the steam system. The steam system is critical to the operation of the CEP and ACF and therefore should only be shut down during an emergency condition.

1. If fuel oil is used, operate all soot blowers before taking the unit off the line.

2. Gradually reduce the load and run boiler to low fire position.

3. With the burner in low fire position, blowdown boiler along with water column gage glass and feed water regulator. Turn the boiler off in accordance with the instructions in the burner manual.

4. If natural gas is used, close manual gas shutoff cock.

5. When the drum pressure falls below 25 psig, open the top drum vent valve.

6. The boiler should be filled with treated hot water in preparation for the next start up.

1.5 Emergency Procedures

Emergency procedures are included with Corrective Maintenance (Troubleshooting) in section 1.12.

1.6 Environmental Considerations

The boilers are required to comply with the requirements of 1990 Clean Air Act, specifically Title I and Title V.

1.7 Safety Instructions

The following safety instructions are provided as general guidelines for persons working on or around the Steam System. The safety instructions should be expanded and appended by the operational staff as the equipment changes. Refer to the general safety procedures at the beginning of each volume for *General Safety Instructions.*

1. The operation and maintenance of the boiler plant equipment shall be carried out by suitably trained personnel.

2. Before working on or operating the boiler plant equipment, all relevant manufacturer's instructions should be read and the requirements of associated

equipment considered.

3. During maintenance procedures, the equipment shall be isolated from the main electrical, fuel oil, steam, gas and high pressure air supplies for the system being maintained.

4. Always ensure that all pressure has been dissipated, and that fluid temperatures are down to safe working limits before dismantling system pipelines and components.

5. Prior to carrying out hydraulic tests on systems, the normal system pressure gauges and pressure switches must be isolated to prevent damage. Suitable hydraulic gauges should be fitted to monitor test pressures employed.

6. Recommended procedures must be carried out when called for by the manufacturers of the equipment or as part of the operator's standing safety regulations (either during normal operating procedure or when required prior to maintenance).

7. System interlocks must not be bypassed.

8. When boiler fuel is switched from oil to gas or vice versa, specific procedures must be followed.

9. An oil gun should never be purged into a hot surface unless the fan is running to first purge the furnace.

10. All machinery supplied with guards must have the prime mover effectively isolated before removal of guards is undertaken for maintenance purposes. The guards must be correctly refitted before the machinery is brought back into operation.

11. During maintenance, the following procedures must be followed:

    - Steam lines should be isolated, and whenever possible there should be two valves providing isolation.

    - Oil lines must be isolated as stated above.

    - Gas lines should be isolated as stated above. The gas lines should be vented outside the boiler plant atmosphere, and purged with nitrogen. The gas should not be allowed to escape via block valves into the boilers or the boiler plant.

    - Normal safety precautions must be taken to avoid the possibility of electrical shock.

1.8 Valve List

The following valve list will be completed once a valve list is received from the construction contractor:

Valve #	Size	Location	Serves	Type	Normal Position

1.9 Operator Servicing Requirements

The operator servicing requirements are defined as maintenance tasks that need to be performed on a daily basis. Regularly scheduled maintenance tasks that are performed less frequently (e.g., weekly, monthly) are classified as preventive maintenance and are described in sections 1.10 and 1.11.

1. Blowdown boiler water column once every shift.

2. Blowdown intermittent blowdown once every shift.

3. When burning fuel oil operate soot blowers once every shift.

4. Clean the observation ports during periods of low fire or shutdown.

5. Record fuel oil usage.

6. Clean intake silencer every shift.

7. Check sample of boiler water, every shift, in accordance with procedures recommended by water treatment consultant.

8. Check burner operation, fuel pressure and atomizing steam pressure.
9. At the beginning of every shift check for unusual noise, improper gauge readings, leaks or signs of overheating.

10. Check the condition of all the refractory and expansion joints.

11. Check boiler alarm and indicator lights.

12. Burner operation: Inspect flame for unusual flame pattern.

Normal Operating Parameters:

Steam header supply, temperature . . . . . 353 deg F
Steam header supply, pressure . . . . . 125 psig
Deaerator, pressure . . . . . 10 psig
Deaerator, temperature . . . . . 240°F

1.10 Preventive Maintenance (PM) Plan

Preventive Maintenance for the Steam System is composed of two parts. This section is a PM Plan, which for each equipment type in the CEP, provides the PM procedures numbers, frequency and time standards. The section is arranged by equipment type.

Section 1.11 contains the PM procedures for the CEP equipment. The section is arranged by PM procedure number.

PM Plan: Steam System			
Equipment Description	**Equipment #**	**PM #**	**Frequency**
Boilers	B-109, B-110	010001	Weekly
		010002	Monthly
		010003	Semiannual
		010004	Annual
Pressure Reducing Valves	PCV - 0069, 0070, 0072, 0074, 0076	010005	Monthly
		010006	Semiannual
		010007	Annual
Soot Blowers	B-105, B-106, B-107, B-108, B-109, B-110	010008	Semiannual

1.11 Preventive Maintenance (PM) Procedures

Task #: 010001	Description: Boilers (B-109, B-110)
Time Required: 0.45h	**Frequency:** Weekly
Skill Level: Operating Engineer	
Special Tools: none	
Safety Precautions: Follow safe working procedures around steam generating equipment. Refer to __	

Step 1. Burner operation: check burner internals (through view port) for indications of any burner malfunction.

Step 2. Inspect water column, gage glass, and water level system. Ensure correct water level. Inspect feedwater regulator control and pump operation. Be sure all valving is in the automatic position.

Step 3. Manually test the low water cut off by using the alarm test switch. Depress switch and check alarms. Burner will still operate normally.

Task #: 010002	Description: Boilers (B-109, B-110)
Time Required: 1.5h	**Frequency:** Monthly
Skill Level: Operating Engineer	
Special Tools: none	
Safety Precautions: Follow safe working procedures around steam generating equipment. Use lock out / tag out procedures for fuel lines. Refer to _____	

Step 1. Empty fuel strainers of the oil, gas, and ignitor lines.

Step 2. Low water cut off (Magnetrol)

A. Inspect mercury switches for cracks and short circuit damage.
B. Inspect dry contacts for wear or misalignment.
C. Check insulation on electrical wires for cracks or deterioration.
D. Verify tightness of electrical connections.
E. Check to be sure switch housing cover is back in place.
F. Test operation of unit and alarm indications.

Step 3. Verify correct boiler operating pressure and temperature range. Record cut-in and cut-out set points.
Cut-in point:_____ psig.
Cut-out point:_____ psig.

Step 4. Bottom blow boiler if required by water treatment company.

Task #: 010003	Description: Boilers (B-109, B-110)
Time Required: 16.0h	**Frequency:** Semiannual or scheduled maintenance shut down
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions: To shut down boiler for maintenance refer to **OMSI** manual. Notify _____ prior to shutdown. Follow lock out / tag out procedures for steam, fuel, water valves and electric power.	

Step 1. Inspect windbox internals for loose or damaged items.

Step 2. Inspect swirler from furnace for distortion, heat damage, and damaged welds.

Step 3. Check burner mounting on front wind box face for tears and air leak paths.

Step 4. Inspect poker tips for overheating.

Step 5. Remove and clean scanner lens and view ports.

Step 6. Empty ignitor gas strainers.

Step 7. Check swirler concentricity from the furnace side.

Step 8. Test flame safeguard unit. Check flame failure shut down and positive fuel shut off. Check flame, pilot, ingitor, and burner.

Step 9. Fire side inspection

A. Wire brush furnace area.

B. Check the overall condition of refractory, patch and repair as required, check the following areas:
- Expansion joints in front and rear walls.
- Seals at corners.
- Throat tile.

C. Wash down refractory surfaces with a mixture of high temperature bonding, air-dry type mortar diluted with water, to the consistency of light cream.

D. Inspect breaching and stack for signs of damage, clean if necessary.

E. Replace all gaskets and clean site glasses.

Step 10. Inspect water column assembly probes for leaks and corrosion on connections.

Step 11. Start boiler as per startup procedures in the **omsi** manual. Adjust operation for proper gas readings. (Co, CO_2, NO, O_2, etc.)

Step 12. Check steam safety valve for proper operation as required by local inspector.

Task #: 010004	Description: Boilers (B-109, B-110)
Time Required: 24.0h	**Frequency:** Annual or scheduled maintenance shut down

Skill Level: Boiler Mechanic

Special Tools:

Safety Precautions: To shut down boiler for maintenance refer to **OMSI** manual. Notify _____ prior to shutdown. Follow lock out / tag out procedures for steam, fuel, water valves and electric power.

Step 1. Inspect swirlers for distortion, overheating, loose components, and concentricity.

Step 2. Inspect pokers for overheating, orifice cleanliness, etc.

Step 3. Inspect refractory throat for any damage.

Step 4. Remove and inspect the oil atomization assembly. Remove the atomizer nozzle and inspect for cleanliness.

Step 5. Remove and clean scanner lens and view ports.

Step 6. Empty ignitor gas strainers.

Step 7. Calibrate / test safety interlocks.

Step 8. Test flame safeguard unit. Check flame failure shut down and positive fuel shut off. Check flame, pilot, ingitor, and burner.

Step 9. Fire side inspection

A. Wire brush furnace area.
B. Check the overall condition of refractory, patch and repair as required, check the following areas:
- Expansion joints in front and rear walls.
- Seals at corners.
- Throat tile.
C. Wash down refractory surfaces with a mixture of high temperature bonding, air- dry type mortar diluted with water, to the consistency of light cream.
D. Inspect breaching and stack for signs of damage, clean if necessary.
E. Replace all gaskets and clean site glasses.

Step 10. Water side inspection

A. Drain boiler following omsi manual, open all manhole, handhole access covers and flush out unit with a high pressure water hose.
B. Remove scale or deposits from water side surfaces.
C. Check all water side surfaces and tubes for internal corrosion or leakage.
D. Replace all hand hole and access cover gaskets.
E. Clean low water cut off piping, level contacts, and cross connect piping. Check, clean and blow down all valves and valve piping.
F. Check all water and steam piping valves for leaks, wear, corrosion and other damage. Repair or replace as required.
G. If required punch or turbine the water tubes. (Use factory recommended equipment).

Step 11. Inspect water column assembly probes for leaks and corrosion on connections.

Step 12. Lubricate bearing and stem threads on all bolted bonnet valves.

Task #: 010004	Description: Boilers (B-109, B-110)

Step 13. Soot blower

A. Lubrication
- Sheave wheel, crank or hand wheel drive with light oil in lube holes.
- Grease crank and handwheel using grease fittings.
- Use open gear lubricant on all exposed gears.

B. Inspect poppet valve for steam or air leaks. Reface valve seat or disk if required.

C. Inspect valve steam packings, tighten in a clockwise direction if leaking.

D. Check swivel tube packing for leaks tighten if necessary.

Step 14. Start boiler as per startup procedures in the **OMSI** manual. Adjust operation for proper gas readings. (CO, CO_2, NO, O_2,)

Step 15. Check steam safety valve for proper operation as required by local inspector. Repair to factory specifications, or replace unit if leaking or not operating properly.

Task #: 010005	Description: Pressure Reducing Valves (PCV)
Time Required: 0.5 h	**Frequency:** Monthly
Skill Level: Operating Engineer	
Special Tools: none	
Safety Precautions: Follow safe working procedures around steam generating equipment.	
Step 1. Report any system leaks. Step 2. Inspect pressure gauges; replace if damaged. Step 3. Check and adjust pressure setting.	

Task #: 010006	Description: Pressure Reducing Valves (PCV)
Time Required: 3h	**Frequency:** Semiannual
Skill Level: Operating Engineer	
Special Tools: none	
Safety Precautions: Follow safe working procedures around steam generating equipment. Refer to __	
Step 1. Check system strainers; replace if damaged. Step 2. Clean system strainers. Step 3. Check pressure gauges. Replace or calibrate if defective.	

Task #: 010007	Description: Pressure Reducing Valves (PCV)
Time Required: 5h	**Frequency:** Annual
Skill Level: Operating Engineer	
Special Tools: none	
Safety Precautions: Follow safe working procedures around steam generating equipment.	

Step 1. Check relief valve; replace if defective.

Step 2. Check and adjust pressure settings.

Step 3. Check traps for dirt and foreign matter. Clean if necessary. Replace faulty traps.

Step 4. Drain and clean flash tank.

Step 5. Inspect flash tank for corrosion. Repair or replace if damaged.

Step 6. Every three years, open the pressure reducing valves. Inspect for wear and replace worn parts; renew gaskets and other rubber parts.

Task #: 010008	Description: Soot Blowers
Time Required: 4h	**Frequency:** Semiannual
Skill Level: Boiler Mechanic	
Special Tools:	
Safety Precautions:	

Step 1. Lubricate with light oil, the hub on the sheave wheel and gear.

Step 2. Lubricate with grease the crank and handwheel brackets.

Step 3. Check the seat and disc mating faces of the poppet valve. If warped, regrind or lap.

Step 4. Turn the packing nut of the poppet valve if there is any steam leakage observed.

1.12 Corrective Maintenance (Troubleshooting)

#	Problem	Probable Cause and Corrective Action
1.	**General**	
	Procedures for the system presented here relate to system functioning only. The following steps should be incorporated into each troubleshooting procedure whenever related equipment has been shut down by an actuated alarm or a system component breakdown. Depending upon the nature of the trouble, take whatever precautions are necessary to safeguard personnel, property and equipment. Determine the most likely causes of the system malfunction and, by the process of elimination, find the actual cause. Correct the faulty condition. A check of corrective measures must be taken to prevent a reoccurrence. Activate the repaired equipment and ascertain that it works properly. Return the system to normal operation.	
2.	**Burner will not start**	**1. Main disconnect switch open**
		A. Verify that the burner disconnect switch is in the closed position.
		2. Lack of ignition spark
		A. Check electrical connections, ignition, circuits and interlocks; repair or replace as necessary.
		3. No ignition gas
		A. Check that there is natural gas flow to the burner pilot.
		B. Check that the natural gas pilot train piping is properly set; make the necessary repairs or replacements as required.
		C. Verify that the shutoff plug cocks are in the fully "open" position.

#	Problem	Probable Cause and Corrective Action
		D. Check that there is electrical power to the natural gas pilot safety shut-off valves and that they are in the "open" position; make repairs as necessary.
		4. Insufficient natural gas supply main fuel
		A. Check that the natural gas train piping is properly set; make the necessary repairs or replacements as required.
		B. Check that the natural gas shut-off plug cocks (inlet and outlet) are in the "open" position.
		C. Check that there is electrical power to the natural gas safety shut-off valves and that they are in the "open" position; make repairs as necessary.
		5. Insufficient fuel oil supply
		A. Check that the fuel oil train piping is properly set; make the necessary repairs or replacements as required.
		B. Check that the fuel oil shut-off plug cocks (inlet and outlet) are in the "open" position.
		C. Check that there is electrical power to the kerosene fuel oil safety shut-off valves and that they are in the "open" position; make repairs as necessary.
		D. Verify that the fuel oil system pump is operational; repair as necessary.
		E. Verify that there is fuel oil in the fuel oil storage tanks.
		6. Burner management control panel malfunctions or improperly set
		A. Check all control circuits and wiring; make repairs as necessary.

#	Problem	Probable Cause and Corrective Action
		B. Check settings on control panel; make adjustments as required.
		7. Heating element overheats
		A. Allow heating element to cool for at least 3 minutes and attempt re-start.
		8. Insufficient or no feedwater supply to the boilers
		A. Verify that the feedwater isolation valves to the selected steam boiler are in the fully "open" position, including those at the inlet & outlet of the boiler economizer.
		B. Verify that the designated boiler feedwater pump discharge valve is in the fully "open" position.
		C. Verify that the designated boiler feedwater pump is operational; check for pump malfunctioning, repair as necessary.
		D. Check that the boiler feed water flow control valve to the boiler is functioning properly; check controls, repair or replace as necessary.
		E. Feedwater supply to a boiler is controlled by the respective boiler steam flow and boiler drum level. The respective feedwater flow control valve will automatically modulate the flow to the respective boiler.
		9. Designated boiler feedwater pump is not operating
		A. Check pump disconnect switch; switch should be in the "ON" position.
		B. Check pump "H-O-A" switch; switch should be in "AUTO" position.
		C. Check motor overload heaters for continuity and proper sizing, replace if necessary.

#	Problem	Probable Cause and Corrective Action
		D. Check fused disconnect switch in motor circuit for proper seating of switch, proper size fuse and contact.
		E. Repair or replace pitted or worn out disconnects.
		10. Insufficient or no treated make-up water to the deaerating heater
		A. Verify that the treated make-up water isolation valves to the deaerating heater are in fully "OPEN" position.
		B. Verify that the treated make-up water level control valve is functioning properly; check controls, repair or replace as necessary.
		11. Treated water pumps are not operating (primary supply of water to the deaerator)
		A. Check pump disconnect switch; switch should be in the "ON" position.
		B. Check pump "H-O-A" switch; switch should be in "AUTO" position.
		C. Check motor overload heaters for continuity and proper sizing, replace if necessary.
		D. Check fused disconnect switch in motor circuit for proper seating of switch, proper size fuse and contact.
		E. Repair or replace pitted or worn out disconnects.
3	**Burner Shutdown occurs during Firing**	**1. Loss of natural gas supply**

#	Problem	Probable Cause and Corrective Action
		A. Verify that there is sufficient natural gas supply from the main. Verify that the natural gas supply is at the correct pressure (10 psig at the inlet to the gas train). Switch to the fuel oil if no immediate solution can be found.
		B. Check for proper functioning of the flame detector; repair or replace as necessary. The flame detector scans the flame and will cause an immediate shutoff of all fuel in the case of flame failure.
		C. Verify that the natural gas safety shut-off valves are functioning properly; repair or replace as necessary.
		D. Check for an electrical malfunction in the safety shut-off valve(s) circuit; repair or replace as necessary.
		2. Loss of fuel oil supply
		A. Verify that there is sufficient fuel oil supply from the storage tank(s). If not check for a malfunction in the fuel oil system from the storage tanks to the pumps. (For fuel oil system see system 4.) make repairs and/or replacements as necessary.
		B. Check for proper functioning of the flame detector; repair or replace as necessary. The flame detector scans the flame and will cause an immediate shutoff of all fuel in the case of flame failure.
		C. Verify that the fuel oil safety shut-off valves are functioning properly; repair or replace as necessary.
		D. Check for an electrical malfunction in the safety shut-off valve(s) circuit; repair or replace as necessary.
		3. Insufficient feedwater supply to the boilers

#	Problem	Probable Cause and Corrective Action
		A. Verify that the feedwater isolation valves to the selected steam boiler are in the fully "open" position, including those at the inlet & outlet of the boiler economizer.
		B. Verify that the designated boiler feedwater pump discharge valve is in the fully "open" position.
		C. Verify that the designated boiler feedwater pump is operational; check for pump malfunctioning, repair as necessary.
		D. Check that the boiler feed water flow control valve to the boiler is functioning properly; check controls, repair or replace as necessary.
		E. Feedwater supply to a boiler is controlled by the respective boiler steam flow and boiler drum level. The respective feedwater flow control valve will automatically modulate the flow to the respective boiler.
		4. Boiler burner trips-out, burner management safety condition has been violated
		A. Check if safety condition(s) have been alarmed on the Panalarm annunciator. All safety conditions violated must be corrected before boiler can be restarted. If controls are malfunctioning, repair or replace as necessary.
4.	**Burner stays in low fire**	**1. Either fuel, natural gas or fuel oil, pressure limit is above the operating control set point**
		A. Reset the fuel pressure to the correct operating set point.
		2. Natural gas temperature limit is above the operating control set point

#	Problem	Probable Cause and Corrective Action	
		A	Reset the natural gas temperature to the correct operating set point.
		3.	**When operating with fuel oil, the steam atomization pressure to the burner is set too low**
		A	Reset the steam operating pressure at the boiler master control panel.
		4.	**Manual/automatic switch in the plant master controller is in the wrong position**
		A	Reposition manual/automatic switch to "AUTOMATIC". Burner firing rate will then be controlled by the respective boiler master controller via the plant master controller.
		B.	If the controls are malfunctioning, repair or replace as necessary.
5.	**No feed water to the boiler**	**1.**	**Insufficient feedwater supply to the boilers**
		A.	Verify that the feedwater isolation valves to the selected steam boiler are in the fully "open" position, including those at the inlet & outlet of the boiler economizer.
		B.	Verify that the designated boiler feedwater pump discharge valve is in the fully "open" position.
		C.	Verify that the designated boiler feedwater pump is operational; check for pump malfunctioning, repair as necessary.
		D.	Check that the boiler feed water flow control valve to the boiler is functioning properly; check controls, repair or replace as necessary.

#	Problem	Probable Cause and Corrective Action
		E. Feedwater supply to a boiler is controlled by the respective boiler steam flow and boiler drum level. The respective feedwater flow control valve will automatically modulate the flow to the respective boiler.
		2. Designated boiler feedwater pump is not operating
		A. Check pump disconnect switch; switch should be in the "ON" position.
		B. Check pump "H-O-A" switch; switch should be in "AUTO" position.
		C. Check motor overload heaters for continuity and proper sizing, replace if necessary.
		D. Check fused disconnect switch in motor circuit for proper seating of switch, proper size fuse and contact.
		E. Repair or replace pitted or worn out disconnects.
		3. Insufficient or no treated make-up water to the deaerating heater
		A. Verify that the treated make-up water isolation valves to the deaerating heater are in fully "OPEN" position.
		B. Verify that the treated make-up water level control valve is functioning properly; check controls, repair or replace as necessary.
		4. Insufficient or no treated make-up water to the deaerating heater
		A. Verify that the treated make-up water isolation valves to the deaerating heater are in fully "OPEN" position.

#	Problem	Probable Cause and Corrective Action
		B. Verify that the treated make-up water level control valve is functioning properly; check controls, repair or replace as necessary.
		5. Treated water pumps are not operating (primary supply of water to the deaerator)
		A. Check pump disconnect switch; switch should be in the "ON" position.
		B. Check pump "H-O-A" switch; switch should be in "AUTO" position.
		C. Check motor overload heaters for continuity and proper sizing, replace if necessary.
		D. Check fused disconnect switch in motor circuit for proper seating of switch, proper size fuse and contact.
		E. Repair or replace pitted or worn out disconnects.
6.	**No Steam Supply to the Facility Site Distribution System**	**1. Improper Valve Positioning**
		A. Verify that the boiler outlet steam supply isolation valves to the steam header and the distribution facility are all in the fully "OPEN" position. This includes isolation valves at the pressure reducing valve stations.
		2. Insufficient or no feedwater supply to the boilers
		A. Verify that the feedwater isolation valves to the selected steam boiler are in the fully "open" position, including those at the inlet & outlet of the boiler economizer.

#	Problem	Probable Cause and Corrective Action
		B. Verify that the designated boiler feedwater pump discharge valve is in the fully "open" position.
		C. Verify that the designated boiler feedwater pump is operational; check for pump malfunctioning, repair as necessary.
		D. Check that the boiler feed water flow control valve to the boiler is functioning properly; check controls, repair or replace as necessary.
		E. Feedwater supply to a boiler is controlled by the respective boiler steam flow and boiler drum level. The respective feedwater flow control valve will automatically modulate the flow to the respective boiler.
		3. Designated boiler feedwater pump is not operating
		A. Check pump disconnect switch; switch should be in the "ON" position.
		B. Check pump "H-O-A" switch; switch should be in "AUTO" position.
		C. Check motor overload heaters for continuity and proper sizing, replace if necessary.
		D. Check fused disconnect switch in motor circuit for proper seating of switch, proper size fuse and contact.
		E. Repair or replace pitted or worn out disconnects.
		4. Insufficient or no treated make-up water to the deaerating heater
		A. Verify that the treated make-up water isolation valves to the deaerating heater are in fully "OPEN" position.

#	Problem	Probable Cause and Corrective Action
		B. Verify that the treated make-up water level control valve is functioning properly; check controls, repair or replace as necessary.
		5. Treated water pumps are not operating (primary supply of water to the deaerator)
		A. Check pump disconnect switch; switch should be in the "ON" position.
		B. Check pump "H-O-A" switch; switch should be in "AUTO" position.
		C. Check motor overload heaters for continuity and proper sizing, replace if necessary.
		D. Check fused disconnect switch in motor circuit for proper seating of switch, proper size fuse and contact.
		E. Repair or replace pitted or worn out disconnects.
		6. Insufficient or no treated make-up water to the deaerating heater
		A. Verify that the treated make-up water isolation valves to the deaerating heater are in fully "OPEN" position.
		B. Verify that the treated make-up water level control valve is functioning properly; check controls, repair or replace as necessary.
7	**Insufficient or no High Pressure Steam Supply**	**1. Isolation valves partially of fully closed.**
		A. Verify that all the isolation valves to all the users are in the fully “OPEN” position.
		2. Boiler(s) not operating at correct pressure.

#	Problem	Probable Cause and Corrective Action
		A. Verify that the boiler is operating at the correct set pressure.
8	**Insufficient or No Low Pressure Steam Supply to Deaerator**	**1. Isolation valves partially or fully closed.**
		A. Verify that all the isolation valves to all the users are in the fully "OPEN" position.
		2. Steam pressure reducing valve(s) (in pressure reducing station(s)) malfunctioning under normal load conditions
		A. Check pressure reducing valves for proper functioning.
		B. Dirt or foreign material between pilot valve seat and head. Loosen pressure adjustment screw. Remove control pressure and valve outlet copper tubing connections at bottom flange pilot. Remove and inspect pilot head and seat assembly and clean; if worn replace.
		C. Dirt and foreign matter are on main valve stem and guide. Remove, inspect and clean.
		3. Steam pressure reducing valve fails to open
		A. Pressure reducing valve diaphragm ruptured. Unscrew control pressure copper tubing at the valve diaphragm cover plate and inspect case. If diaphragm is defective it must be replaced.
		B. Valve diaphragm cover plate orifice is plugged, remove fitting and clean.
		C. Pilot valve seat is plugged. Remove pilot head and seat assembly, inspect, clean and/or replace.

#	Problem	Probable Cause and Corrective Action
		D. Pipeline strainer is clogged, remove screen and clean.
		E. Pilot valve pressure adjustment screw is not properly set. To adjust pressure, turn screw to the required setting.
		4. Steam pressure leaving reducing valve too low
		A. Pilot valve pressure adjustment screw is not properly set. Turn screw to desired pressure setting.
		B. Steam supply pressure is too low. Check for clogged strainer, partially closed valves at, or ahead of station.
		C. Valve diaphragm is ruptured. Unscrew control pressure copper tubing to main diaphragm cover plate and inspect case. If diaphragm is defective it must be replaced.
9	**Steam Trap does not Work Properly**	**1. Cold trap - No condensate discharge from trap.**
		A. Condensate or steam does not reach trap. Check for plugged strainer or condensate piping.
		B. Condensate or steam does not reach trap. Check for broken valve in piping to steam trap.
		C. Trap seat components worn or defective. Repair or replace trap.
		D. Trap body may be filled with dirt particles. Remove trap and clean.
		E. Defective air vent on float traps and thermostatic traps will cause air binding. Verify proper venting of traps.
10	**Steam Loss**	**1. Trap blows line pressure steam.**
		A. Valve fails to seat, scale may be lodged in orifice.

#	Problem	Probable Cause and Corrective Action
		B. Valve fails to seat, components may be worn.
11	**Continuous Flow through Trap**	**1. Trap does not cycle.**
		A. Trap may be too small. Install a larger capacity trap or an additional trap in parallel piping.
		B. Trap may be too small. A higher pressure trap may have been installed for low pressure application.
12	**Excessive Make-up Water required for Steam System**	**1. Significant increase in amount of make-up water required.**
		A. Verify that the required make-up water is within the expected amount.
		2. Condensate pumps not operating.
		A. Verify that the condensate pumps are operational; check for pumps malfunctioning; repair or replace as necessary.
		3. All condensate not returned
		A. Verify that all the expected condensate is being returned to the deaerator and not being dumped.
		4. Steam traps malfunctioning.
		A. Repair or replace as required.
13	**Valve Leaks**	**1. Valve stem packing deteriorated or improper.**
		A. Repack valve.
		2. Roughness of valve stem.
		A. Repair valve stem or replace valve if necessary.
		3. Flange gasket deteriorated.
		A. Clean surface and install new gaskets.

#	Problem	Probable Cause and Corrective Action
14	**Piping Leaks**	**1. Excessive stress at joints due to vibration of equipment and/or piping.**
		A. Isolate area and repair or replace damaged piping and/or equipment.
		2. Freeze up in piping
		A. Isolate area and repair or replace damaged piping
15	**Soot Blower Cannot Rotate Easily**	**1. Element binding in bearings in boiler**
		A. Check alignment of bearing and correct if misaligned. Straight element if bent.
		2. Cam loose on drive gear, binding trigger.
		A. Tighten attaching bolts.
		3. Drive gears jammed
		A. Clean debris or paint from pinion and gear teeth
		4. Positive closing pin on drive gear in wrong position, binding trigger.
		A. Relocate pin so it will pass by lug on trigger as valve closes.
		5. Swivel tube packing too tight.
		A. Loosen packing.
		6. Valve stem fouled, binding in valve stem guide
		A. Correct cause of binding. Replace stem if damaged.
		7. Valve stem fouled, binding in valve stem guide.
		A. Correct cause of binding. Replace stem if damaged.

#	Problem	Probable Cause and Corrective Action
		8. Flexible element connection assembly (where used) frozen, does not flex with boiler expansion, transmits strain to head.
		A. Repair or replace connection assembly.
		9. Piping incorrectly supported, transmits strain to heads.
		A. Readjust piping supports.
		10. Thrust bearing rusted, freezing swivel tube.
		A. Clean and lubricate bearing.
16	**Blowing Medium Fails to shut off soot blower**	**1. Valve stem sticking in guide**.
		A. Loosen packing. Lubricate stem with hi-temp lubricant.
		2 Valve yoke broken or bent off from valve stem.
		A. Replace yoke.
		3. Valve spring broken.
		A. Replace spring.
		4. Valve disc loose from valve stem.
		A. Reassemble disc to stem.
17	**Element fails to rotate (cleaning inadequate)**	**1. Steam not leaking out wallbox** **(a) Set screw in drive gear loose from swivel tube (locknut loose).** **(b) Element broken off just inside furnace (excess moisture).**
		A. (a) Engage set screw in spot-faced hole in collar on tube. (b) Repair by welding or replace.

#	Problem	Probable Cause and Corrective Action
		2. Steam leaking out wallbox **(a) Swivel tube destroyed.** **(b) Couping broken inside wallbox.** **(c) Element unscrewed from coupling (set screws not tight)**.
		A. (a) Replace. (b) Replace. (c) Reassemble and tack weld.
18	**Tube abrasion or baffle erosion present upon internal inspection**	**1. Blowing pressure too high.**
		A. Reduce pressure.
		2. Nozzle alignment with tubes incorrect.
		A. Realign element with arrow on large gear.
		3. Blowing arc incorrect.
		A. Modify cam length.
		4. Excess moisture present in steam.
		A. Add condensate drain to supply pipe.
		5. Too frequent an operating cycle observed.
		A. Reduce blowing frequency.
19	**Frequent breakage of di-alloy elements experienced**	**1. Temperature zone too cool, Di-alloy not suitable in 1000 degree - 1400 degree F zones, crystalline fracture**.
		A. Use calorized steel.
		2. Excess moisture in steam **(a) Improper piping warm-up** **(b) Improper piping drainage, no slope, connected to "blow down" tank positive pressure.** **(c) No condensate reservoir, piping experience high radiation loss.**

#	Problem	Probable Cause and Corrective Action
		A. (a) Allow longer warm-up time. (b) Add piping drain slope. (c) Increase condensate reservoir and provide additional condensate discharge capacity.
20	**Nozzles on elements cutting out "wire drawn"**	**1. Excess moisture in steam**.
		A. Add condensate drain in supply water.
21	**Elements warping to where bearings are binding**	**1. Improperly supported, insufficient number of bearing used for ambient temperature in that zone**.
		A. Straight element and add intermediate bearing.
		2. Bearing improperly aligned at erection.
		A. Realign bearing.
		3. Boiler tubes misaligned carrying bearings with them.
		A. Realign tubes or add compensating spacers to bearings.
		4. Wallbox improperly set to handle expansion in that area (see installation drawing).
		A Reset wallbox on boiler casing.

1.13 Key Names, Addresses and Telephone Numbers

Cleaver-Brooks (Boiler)
P.O. Box 421
Milwaukee, WI 53201
414-359-0600

Chicago Blower Corporation (Forced Draft Fan)
1675 Glen Ellyn Road
Glendale Heights, IL 60139
708-858-2600

Ron-Noc Industries, Inc. (Louver Dampers)
2863 Brodhead Road
Bethlehem, PA 18017
610-974-8880